National Aeronautics and Space Administration

NASA

EXPLORESPACE TECH

Advanced Power Systems

September 2020

Advanced Power Systems

- STMD Strategic Plan - Thrust Areas
- NASA Power Systems of Interest
- Technology Areas of Interest
  - Power Generation
  - Power Management and Distribution
  - Energy Storage

STMD Strategic Plan / Thrust Areas

LEAD

Ensuring American global leadership in Space Technology

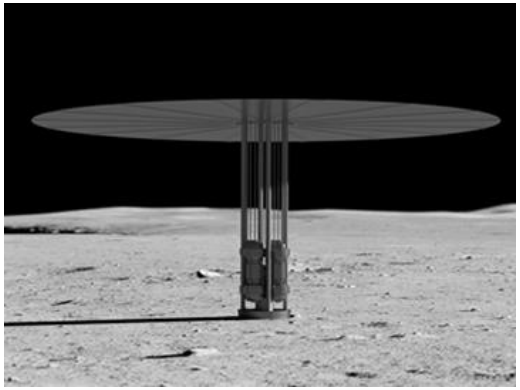
- **Lunar Exploration building to Mars and new discoveries at extreme locations**
- **Robust national space technology engine to meet national needs**
- **U.S. economic growth for space industry**
- **Expanded commercial enterprise in space**

Note: Multiple Capabilities are cross cutting and support multiple Thrusts. Primary emphasis is shown

THRUSTS	CAPABILITIES
 ***Go*** ***Rapid, Safe, & Efficient Space Transportation***	• Advanced Propulsion • Cryogenic Fluid Management
 ***Land*** ***Expanded Access to Diverse Surface Destinations***	• Human & Robotic Entry, Descent and Landing • Precision Landing
 ***Live*** ***Sustainable Living and Working Farther from Earth***	• Advanced life support and human performance • Advanced Materials, Structures and Manufacturing • Advanced Power Systems • In-situ Propellant and Consumable Production • Autonomous Systems and Robotics
 ***Explore*** ***Transformative Missions and Discoveries***	• On-Orbit Servicing, Assembly and Manufacturing • Small Spacecraft Technologies • Advanced Avionics • Advanced Communications and Navigation

NASA Power Systems of Interest

- Solar Power Systems
  - International Space Station, Satellites, SEP
  - PV Array, Battery, RFC, PMAD
- Nuclear Power Systems
  - Surface Power, NEP, RPS
  - Energy Conversion, Power Generation, PMAD
- Ancillary Power Systems
  - Rovers, Suits, Landers
  - RPS, Fuel cells, Battery, PMAD



Power Generation Technology Areas of Interest

		Power Generation												
	Tech No.	1	2	3	4	5	6	7	8	9	10	11	12	13
	Power Technologies	RPS	RPS	RPS	Fission	Fission	Fission	Solar PV	Solar PV	Solar PV	Solar Concentrators	Primary Batteries	Primary Fuel Cells	CHIPS
Missions	Target power/voltage	<1 W	100 W	1 kW	≤10 kW	50-100 kW	>1 MW	≤10 kW	20-50 kW	>100 kW	20-50 kW	1 kW	1 kW	1 kW
GO														
Human Lunar SEP	50 kW													
Human Mars SEP	300 kW													
Human Mars NEP	>1 MW													
Robotic Science SEP	<20 kW													
Robotic Science REP	<1 kW													
Robotic Science NEP	<20 kW													
LAND														
Lunar CLPS-Class	<5 kW													
Lunar HLS-Class	<10 kW													
Human Mars Lander	<10 kW													
LIVE														
Lunar Hab	10-20 kW													
Lunar ISRU - Propellant Demo	10-20 kW													
Lunar ISRU - Propellant Production	100s kW													
Lunar ISRU - Construction	10-20 kW													
Lunar Unpressurized Rover	2 kW													
Lunar Pressurized Rover	5-10 kW													
Mars Hab	10-20 kW													
Mars ISRU - MAV Fueling	20-40 kW													
Mars ISRU - Propellant Production	100s kW													
Mars Pressurized Rovers	5-10 kW													
EXPLORE														
Small Spacecraft & Cubesats	<1 kW													
Science Probes, < Earth	500 W													
Science Probes, Earth to Jupiter	1-5 kW													
Science Probes, > Jupiter	1 kW													
Interstellar Probe	tbd													
Lunar Astronomy	5-10 kW													
Lunar Science Rovers	<2 kW													
Mars Science Rovers	<2 kW													
Aerial Vehicles	<1 kW													
Venus Atmosphere	100 W													
Venus Surface	100 W													
Ocean World Surface	100 W													
Ocean World Sub-surface	tbd													
Ice Giant Surface	200 W													

	Technology is ready for this mission
	Technology is not ready, but is sufficiently funded
	Technology is not ready, and not adequately funded
	Technology is not applicable for the mission

Power Management and Distribution Technology Areas of Interest

		Power Management & Distribution							System	
	Tech No.	18	19	20	21	22	23	24	25	26
	Power Technologies	Converters, Regulators, Switchgear	Converters, Regulators, Switchgear	EP Power Processing Units	EP Power Processing Units	Power Cabling	Power Beaming	Power Beaming	Operations & Sustaining Engr	Autonomous Control
Missions	Target power/voltage	28-160V	300-1000V	<20 kW	>100 kW	>300V	≤10 kW	10-100kW	N/A	N/A
GO										
Human Lunar SEP	50 kW									
Human Mars SEP	300 kW		X			X				
Human Mars NEP	>1 MW									
Robotic Science SEP	<20 kW									
Robotic Science REP	<1 kW									
Robotic Science NEP	<20 kW									
LAND										
Lunar CLPS-Class	<5 kW									
Lunar HLS-Class	<10 kW									
Human Mars Lander	<10 kW									
LIVE										
Lunar Hab	10-20 kW									
Lunar ISRU - Propellant Demo	10-20 kW									
Lunar ISRU - Propellant Production	100s kW									
Lunar ISRU - Construction	10-20 kW									
Lunar Unpressurized Rover	2 kW									
Lunar Pressurized Rover	5-10 kW									
Mars Hab	10-20 kW									
Mars ISRU - MAV Fueling	20-40 kW									
Mars ISRU - Propellant Production	100s kW									
Mars Pressurized Rovers	5-10 kW									
EXPLORE										
Small Spacecraft & Cubesats	<1 kW									
Science Probes, < Earth	500 W									
Science Probes, Earth to Jupiter	1-5 kW									
Science Probes, > Jupiter	1 kW									
Interstellar Probe	tbd									
Lunar Astronomy	5-10 kW									
Lunar Science Rovers	<2 kW									
Mars Science Rovers	<2 kW									
Aerial Vehicles	<1 kW									
Venus Atmosphere	100 W									
Venus Surface	100 W									
Ocean World Surface	100 W									
Ocean World Sub-surface	tbd									
Ice Giant Surface	200 W									

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Energy Storage Technology Areas of Interest

		Energy Storage			
	Tech No.	14	15	16	17
	Power Technologies	Supercaps	Rechargeable Batteries	Regen Fuel Cells	Regen Fuel Cells
Missions	Target power/voltage	1-10 kW-hr	<100 kW-hr	<100 kW-hr	>1000 kW-hr
GO					
Human Lunar SEP	50 kW				
Human Mars SEP	300 kW				
Human Mars NEP	>1 MW				
Robotic Science SEP	<20 kW				
Robotic Science REP	<1 kW				
Robotic Science NEP	<20 kW				
LAND					
Lunar CLPS-Class	<5 kW				
Lunar HLS-Class	<10 kW				
Human Mars Lander	<10 kW				
LIVE					
Lunar Hab	10-20 kW				
Lunar ISRU - Propellant Demo	10-20 kW				
Lunar ISRU - Propellant Production	100s kW				
Lunar ISRU - Construction	10-20 kW				
Lunar Unpressurized Rover	2 kW				
Lunar Pressurized Rover	5-10 kW				
Mars Hab	10-20 kW				
Mars ISRU - MAV Fueling	20-40 kW				
Mars ISRU - Propellant Production	100s kW				
Mars Pressurized Rovers	5-10 kW				
EXPLORE					
Small Spacecraft & Cubesats	<1 kW				
Science Probes, < Earth	500 W				
Science Probes, Earth to Jupiter	1-5 kW				
Science Probes, > Jupiter	1 kW				
Interstellar Probe	tbd				
Lunar Astronomy	5-10 kW				
Lunar Science Rovers	<2 kW				
Mars Science Rovers	<2 kW				
Aerial Vehicles	<1 kW				
Venus Atmosphere	100 W				
Venus Surface	100 W				
Ocean World Surface	100 W				
Ocean World Sub-surface	tbd				
Ice Giant Surface	200 W				

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